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Further considerations regarding the status of *Grosphus madagascariensis* (Gervais) and *Grosphus hirtus* Kraepelin, and description of a new species (Scorpiones, Buthidae)

Wilson R. LOURENÇO[1] & Steven M. GOODMAN[2]

[1] Département de Systématique et Evolution, USM 0602, Section Arthropodes (Arachnologie), Muséum national d'Histoire naturelle, CP 053, 61 rue Buffon, 75005 Paris, France. E-mail: arachne@mnhn.fr

[2] Field Museum of Natural History, Roosevelt Road at Lake Shore Drive, Chicago, Illinois 60605, USA, and WWF, BP 738, Antananarivo (101), Madagascar. E-mail: sgoodman@fieldmuseum.org

Further considerations regarding the status of *Grosphus madagascariensis* (Gervais) and *Grosphus hirtus* Kraepelin, and description of a new species (Scorpiones, Buthidae). - New considerations regarding the species *Grosphus madagascariensis* (Gervais, 1843), type species of the genus *Grosphus* Simon, 1880, and *Grosphus hirtus* Kraepelin, 1900 are proposed, and both species are redescribed. One new species, *Grosphus goudoti* sp. n., is described from the Province d'Antsiranana, Forêt de Bobankora, E of Daraina on the northern range of Madagascar. With this description the total number of known species in this endemic genus is now 15. Some details are presented on the ecological settings of the sites where the described specimens were collected. A revised key to the species of *Grosphus* is given.

Keywords: Scorpiones - Buthidae - *Grosphus* - new species - taxonomy - Madagascar.

INTRODUCTION

As already discussed in recent papers (Lourenço, 2003; Lourenço *et al.*, 2004), the first *Grosphus* species to be described was *Scorpio* (*Androctonus*) *madagascariensis* Gervais, 1843 = *G. madagascariensis* (Gervais, 1843). Kraepelin (1900) contributed to the study of this genus and described several new species, including *G. hirtus*, a species morphologically similar to *G. madagascariensis*. In his monograph on the scorpions of Madagascar, Fage (1929) characterized both species. After Fage's (1929) monograph several new species of *Grosphus* were described (e. g. Lourenço, 2003; Lourenço *et al.*, 2004), and precise diagnoses have been proposed for *G. madagascariensis* and *G. hirtus* (see Lourenço, 1996).

The taxonomy of *Grosphus* is based mainly on two characters: the pattern of coloration and the morphology of the basal middle lamellae of the female pectines.

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This last character has been considered by scorpion taxonomists to be of species specific significance and possess little intraspecific variation. However, more detailed investigations have showed that in some cases closely related species have a similar basal middle lamellae morphology (Lourenço, 2003; Lourenço & Goodman, 2003; Lourenço *et al.*, 2004). On the basis of this character some populations which have been attributed to widely distributed species, such as *G. madagascariensis, G. limbatus*, and *G. bistriatus*, remained undescribed until recently (Lourenço, 2003; Lourenço *et al.*, 2004). Neverless, problems of faulty species identification remains possible in morphologically similar taxa, particularly those named in the early stages of the taxonomy of this genus. This is certainly the case for *G. madagascariensis* and *G. hirtus*.

Grosphus madagascariensis was described on the basis of one single specimen from Madagascar, without any indication of its precise collection locality. The type specimen, deposited in the Museum in Paris, has an associated original label with the distinct handwriting of Gervais reading "*S. goudotii*". A subsequent label written by Kraepelin is more precise and reads *S. goudotii* (*Androctonus*), Madagascar, Goudot. The name *goudotii* was not used in the original publication (Gervais, 1843) and the original label only seems to indicate an intention of Gervais to dedicate this species to the collector Jules Goudot. In Museum collections registration the following remark was written by Vachon: *Androctonus goudotti* Gervais, type = *Grosphus madagascariensis* (Gervais) 1844. The type specimen, presumably a male, is so poorly preserved that only metasomal characters can be observed. The illustrations given by Gervais (1843, 1844) are, however, clear enough to confirm the identity of this specimen as the type of *G. madagascariensis*. *G. hirtus* was described from a precise locality, Makaraingo in the central region of Madagascar, however, the type specimen is a juvenile female.

It is known that Jules Goudot travelled in the regions between the east coast, the region of Tamatave and Sainte-Marie Island. At the time of his journeys, other parts of Madagascar were inaccessible (forbitten) zones to foreign people (see Dorr, 1997 for details of Goudot's journeys). The region of Tamatave (Toamasina) was, and still is, one of the major harbours in Madagascar, a natural point of entry to the island. The Province of Toamasina was visited by Jules Goudot on several occasions while he stayed on Madagascar, so the specimen on which the description of *G. madagascariensis* was based was most probably collected somewhere in the eastern coastal region of the island.

Although *G. madagascariensis* and *G. hirtus* have overlapping areas of distribution, they inhabit different habitats. The first species is common in humid forests, whereas the second lives in more dry deciduous forests (Fage, 1929). Herein we redescribe both *G. madagascariensis* and *G. hirtus* based newly collected material from their typical habitats. One new species, closely associated to the *G. madagascariensis/G. hirtus* group, is described from a distinct forest habitat in northeastern Madagascar, the Forêt de Bobankora, E of Daraina in the Province d'Antsiranana.

TAXONOMIC TREATMENT

Buthidae C.L. Koch, 1837

Grosphus Simon, 1880

Grosphus madagascariensis (Gervais, 1843) Figs 1-4, 9-12

Scorpio (*Androctonus*) *madagascariensis* Gervais, 1843: 129.
Scorpio (*Androctonus*) *madagascariensis* Gervais, 1844: 213.
Grosphus madagascariensis Simon, 1880: 377.
Grosphus madagascariensis Kraepelin, 1899: 33.
Grosphus madagascariensis Kraepelin, 1900: 12.
Grosphus madagascariensis Fage, 1929: 642.
Grosphus madagascariensis Lourenço, 1996: 9.

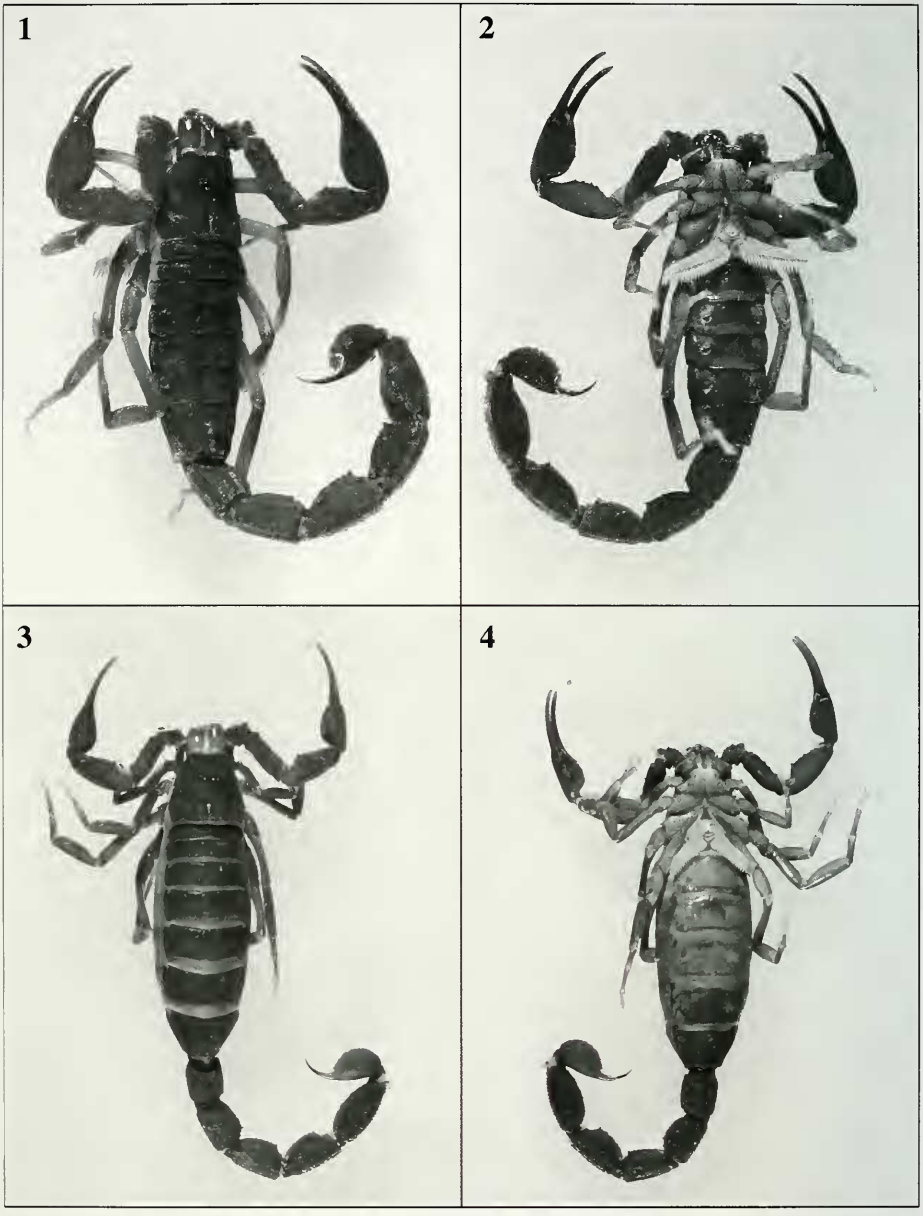
Material: Madagascar, Province de Toamasina, Forêt de Plateau de Makira, Forêt de Vohitaly, site F, 5 km SE village Anjiahely, 15°26'58" S, 49°32'06" E, 540-680 m, 28/XII/2002, pitfall vial marked 'pitfall Vohitaly' (V. Andrianjakarivelo), 1 male, 1 female (MHNG).

Redescription: (based on male and female, measurements in Table I)

Scorpion of medium size, with a total length of 45-60 mm. General coloration reddish brown to dark brown. Carapace and tergites brownish, in females darker than in males; eyes surrounded by black pigment. Metasoma: all segments reddish brown,

Table I. Comparative morphometric values (in mm) of the male and female of *Grosphus madagascariensis* and *G. hirtus* examined and of the male holotype of *G. goudoti* sp. n. and *G. simoni*.

	G. madagascariensis		*G. hirtus*		*G. goudoti* sp. n.	*G. simoni*
	M	F	M	F	M	M
Total length	45.4	52.5	38.9	48.8	59.8	54.2
Carapace:						
- length	5.5	6.2	4.8	6.1	7.2	6.4
- anterior width	4.0	4.4	3.4	4.3	5.3	4.8
- posterior width	6.6	7.6	5.8	6.9	7.9	6.9
Metasomal segment I:						
- length	3.5	4.1	2.8	3.3	5.2	4.5
- width	3.1	3.7	3.1	3.9	4.1	3.4
Metasomal segment V:						
- length	6.5	6.8	5.2	6.6	8.4	7.7
- width	3.1	3.2	2.7	4.1	3.4	3.2
- depth	3.0	3.3	2.8	3.5	3.4	3.3
Vesicle:						
- width	2.7	3.0	2.4	3.3	3.3	2.8
- depth	2.6	2.9	2.2	3.1	3.3	2.9
Pedipalp:						
- femur length	5.4	5.6	4.2	5.2	7.3	6.2
- femur width	1.7	1.9	1.4	1.8	2.2	1.9
- patella length	6.2	6.8	4.9	6.1	8.4	7.1
- patella width	2.5	2.6	2.1	2.7	2.9	2.7
- chela length	10.3	10.8	8.3	9.7	14.3	11.9
- chela width	2.8	2.5	2.5	2.5	3.9	3.1
- chela depth	2.5	2.4	2.3	2.4	3.5	2.8
Movable finger:						
- length	5.9	6.6	4.6	6.0	8.2	6.8



FIGS 1-4

Grosphus madagascariensis. 1-2. Male from Toamasina, dorsal and ventral aspects. 3-4. Female, idem.

with segments IV and V slightly darker; carinae blackish brown. Telson reddish brown; aculeus with reddish base and reddish brown tip. Venter: coxapophysis, sternum, genital operculum and pectines yellowish; sternites greenish yellow. Chelicerae

yellowish, with dark variegated pigmentation; fingers yellowish, with the teeth reddish. Pedipalps reddish, with vestigial variegated spots; legs yellowish in males and reddish in females, with diffused fuscous spots.

Morphology. Carapace moderately granular, more intensely so in females; anterior margin almost straight, with a very discrete median concavity. All carinae moderate to weak; furrows moderately to weakly developed. Median ocular tubercle anterior to centre of carapace; median eyes separated by a little more than one ocular diameter. Three pairs of lateral eyes. Sternum between sub-triangular and sub-pentagonal in shape. Mesosoma: tergites with minute moderately intense granulation. Median carina moderately to weakly developed on all tergites. Tergite VII pentacarinate. Venter: genital operculum consisting of two semi-oval plates. Pectines: pectinal teeth count 20-20 in male and 16-15 in female; basal middle lamella not dilated in males, strongly dilated in females. Sternites smooth, with weakly elongated stigmata. Metasoma: all segments longer than wide, with carinae strongly marked; segments I to III with 10 carinae, crenulate; segment IV with 8 carinae, crenulate. Segment V with 5 carinae. Dorsal carinae on segments II to IV with at least one posterior spinoid granule strongly developed. Intercarinal spaces weakly granular in males, more intensely granular in females. Telson with granules on latero-ventral and ventral surfaces; its dorsal surface smooth; aculeus weakly curved and shorter than the vesicle; subaculear tooth weak to vestigial. Cheliceral dentition characteristic of the family Buthidae (Vachon, 1963); two distinct small basal teeth present on the movable finger; ventral aspect of both fingers and of manus densely set with long setae. Pedipalps: femur pentacarinate; patella with dorsointernal and ventrointernal carinae and with several spinoid granules on the internal face; chela smooth, with vestigial carinae. Fixed and movable fingers with 11/13 oblique rows of granules. Trichobothriotaxy; orthobothriotaxy A-α (Vachon, 1974, 1975). Legs: tarsus with numerous short thin setae ventrally. Tibial spurs present on legs III and IV; pedal spurs present on legs I to IV; all spurs strong.

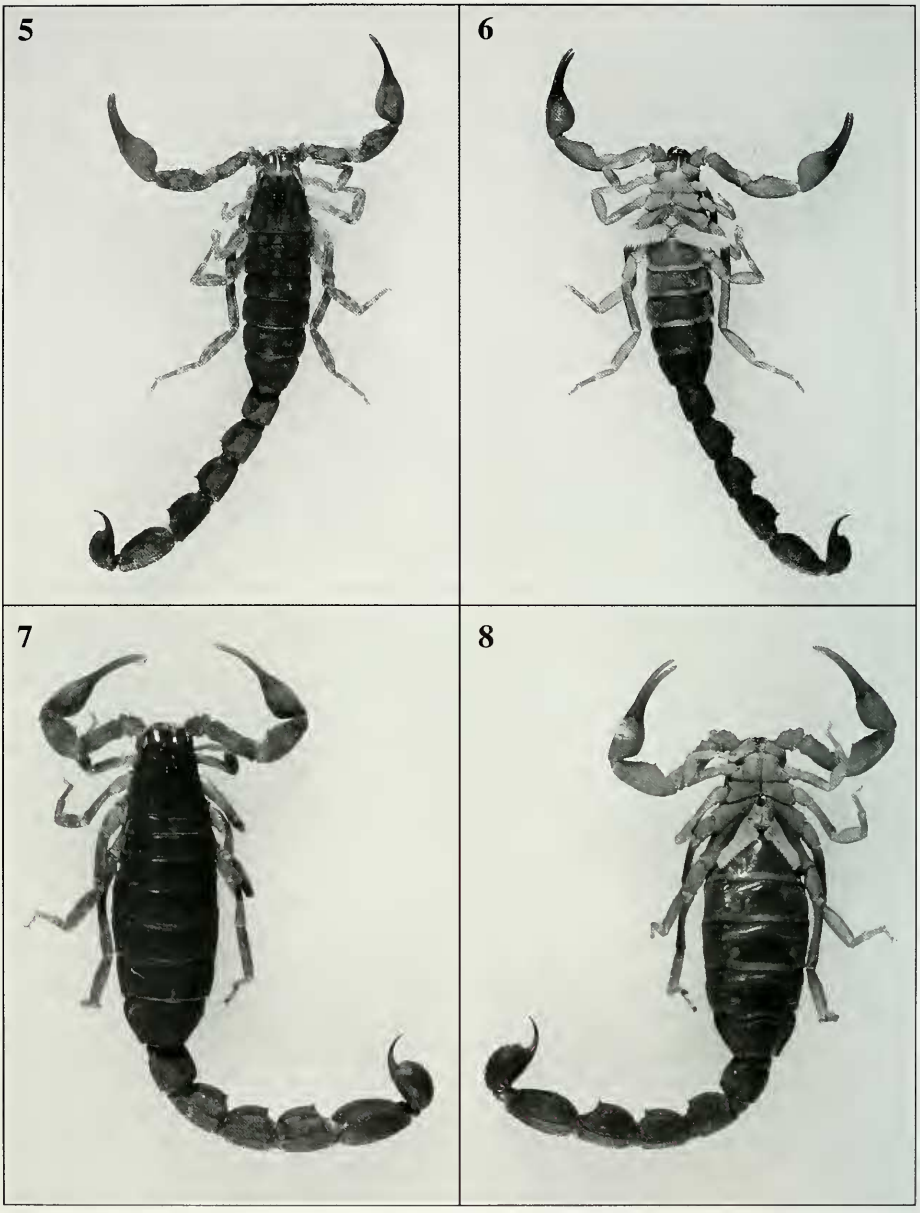
Ecology: The specimens of *Grosphus madagascariensis* examined where collected in a distinct humid lowland forest of eastern Madagascar. The portion of the humid forest is close to the Masoala Peninsula, which receives on average almost 6 m of rainfall per year (Kremen, 2003).

In the Makira Forest, the site where the material was collected, the following species of scorpions were collected by V. Andrianjakarivelo with pit-fall devices during an inventory of small mammals of this region: *Grosphus madagascariensis*, *Grosphus simoni* Lourenço *et al.*, 2004 and *Tityobuthus baroni* (Pocock, 1890).

Grosphus hirtus Kraepelin, 1900 Figs 5-8, 13-15

Grosphus hirtus Kraepelin, 1900: 15.
Grosphus hirtus Fage, 1929: 645.
Grosphus hirtus Lourenço, 1996: 11.

Material: The adult specimens were collected in: Province of Mahajanga, Ankarafantsika Reserve, Forest station of Ampijoroa, Jardin Botanique A (pitfall traps), 16°18'S, 46°48'E, 24-27/II/2001 (G. Garcia Herrero), 1 male, 2 females, 36 juveniles. Juveniles were obtained in the laboratory during the study of the life cycle of the species (all in MHNG).

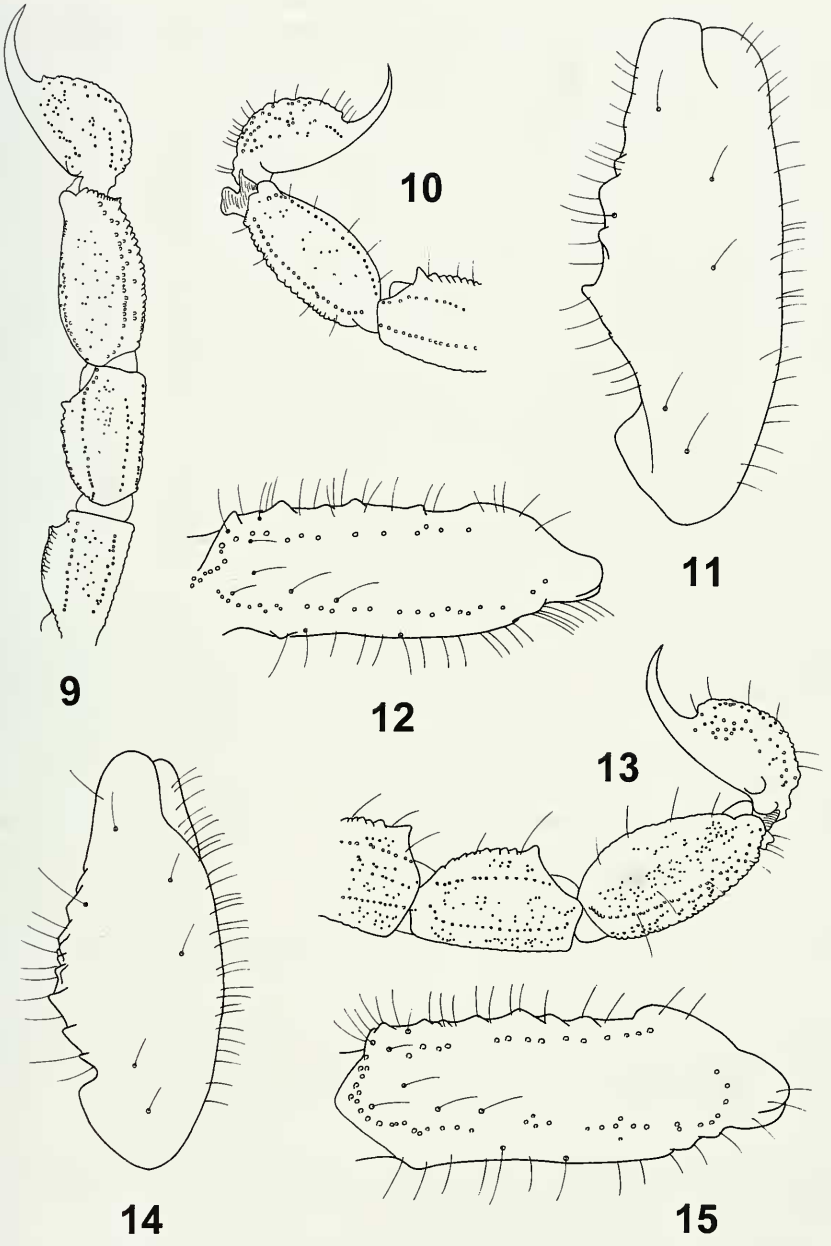


FIGS 5-8

Grosphus hirtus. 5-6. Male from Ankarafantsika, dorsal and ventral aspects. 7-8. Female, idem.

REDESCRIPTION: (based on male and females, measurements in Table I)

Scorpion of medium size with a total length of 40-50 mm. General coloration yellowish to reddish yellow, with variegated brownish spots over body and appendages. Carapace yellowish, with spots more marked on anterior and lateral edges;



FIGS 9-15

9-12. *Grosphus madagascariensis*. 9. Metasomal segments III-V and telson of male holotype, lateral aspect. 10. Metasomal segments IV-V and telson of male from Toamasina, lateral aspect. 11-12. Palpal patella and femur of male from Toamasina, dorsal aspect. 13-15. *Grosphus hirtus*, male from Ankarafantsika. 13. Metasomal segments III-V and telson, lateral aspect. 14-15. Palpal patella and femur, dorsal aspect.

eyes surrounded by black pigment. Mesosoma: yellowish, with confluent dark zones on the posterior edge of tergites. Metasoma: segments I to III yellowish; IV reddish yellow; V reddish; all segments with variegated dark pigmentation; dorsal aspect of segments I to IV each with a triangular spot. Telson reddish, without spots on carinae; aculeus with reddish base and dark reddish tip. Venter: coxapophysis, sternum, genital operculum and pectines yellowish; sternites dark yellow, with V to VII intensely spotted. Chelicerae yellowish, with dark variegated pigmentation throughout; fingers dark brown, with reddish teeth. Pedipalps: reddish yellow with variegated brownish spots. Legs yellowish, with diffused brownish spots.

Morphology. Carapace weakly granular in males, moderately granular in females; anterior margin almost straight, with a weak median concavity. All carinae and furrows weakly developed. Median ocular tubercle anterior to centre of carapace; median eyes separated by one ocular diameter. Three pairs of lateral eyes. Sternum sub-triangular in shape. Mesosoma: tergites with thin but intense granulation. Median carina moderately developed on all tergites. Tergite VII pentacarinate. Venter: genital operculum consisting of two subtriangular plates. Pectines: pectinal tooth count mostly 19-19 in males and 15-15 in females; basal middle lamellae not dilated in males, strongly dilated in females. Sternites smooth, with weakly elongated stigmata; VII with two vestigial carinae. Metasoma: segment I wider than long; segments I to III with 10 carinae, crenulate. Segment IV with 8 carinae, crenulate. Segment V with 5 carinae, crenulate. Dorsal carinae on segments II to IV each with one strong posterior spinoid granule. Intercarinal spaces strongly granular. Telson with a strong granulation on latero-ventral and ventral surfaces; its dorsal surface smooth; aculeus weakly curved and shorter than the vesicle; subaculear tooth vestigial. Cheliceral dentition characteristic of the family Buthidae (Vachon, 1963); two distinct basal teeth present on the movable finger; ventral aspect of both fingers and of manus densely set with long setae. Pedipalps: femur pentacarinate; patella with a dorsointernal carina and with several spinoid granules on the internal aspect; chela smooth, without carinae. Fixed and movable fingers with 11/12 oblique rows of granules. Trichobothriotaxy; orthobothriotaxy A-α (Vachon, 1974, 1975). Legs: tarsus with numerous short thin setae ventrally. Tibial spurs present on legs III and IV; pedal spurs present on legs I to IV; all spurs moderately to strongly developed.

Ecology: The most common native forest formation of the Ankarafantsika region is a dry deciduous forest that occurs on a sandy substrate (Ramangason, 1988). The principal geological formation in the vicinity of the Ampijoroa Forest Station, which includes the Jardin Botanique A, is a plateau that rises to an elevation of 310-340 m above sea level, and this is most likely the zone where the *Grosphus hirtus* specimens treated in this paper were collected. Several different plants occurring in this habitat have varied adaptations to resist desiccation during the pronounced dry season, and different vertebrate species undergo hibernation or torpor to survive this period.

Annual precipitation in the Ankarafantsika area ranges from 1000-1500 mm, most of which falls between the months of November to April (Nicoll & Langrand, 1989). The month of January experiences the heaviest rainfall, with slightly less than 50% of the annual total. A very pronounced dry and cool period occurs between the months of May and September. During this latter period little to no rain falls and the

forest experiences a distinct drought. Monthly mean temperatures range from 17° to 35° C, and the annual average temperature is 26°C.

The scorpion fauna of the Forest Station of Ampijoroa, part of the Parc National d'Ankarafantsika, is composed of *Grosphus hirtus*, *G. ankarafantsika* Lourenço, 2003, *G. garciai* Lourenço, 2001, *Tityobuthus dastychi* Lourenço, 1997, and *Opisthacanthus madagascariensis* Kraepelin, 1894.

Grosphus goudoti sp. n. Figs 16-24

MATERIAL: Madagascar, Province d'Antsiranana, Forêt de Bobankora, versant ouest, site N° 2, 11 km E of Daraina (13°13.414'S, 49°45.586'E), 350-550 m (M. Raheriarisena & H. A. Rakotondravony), X/2002-III/2003, male holotype, deposited in the Muséum d'histoire naturelle, Genève.

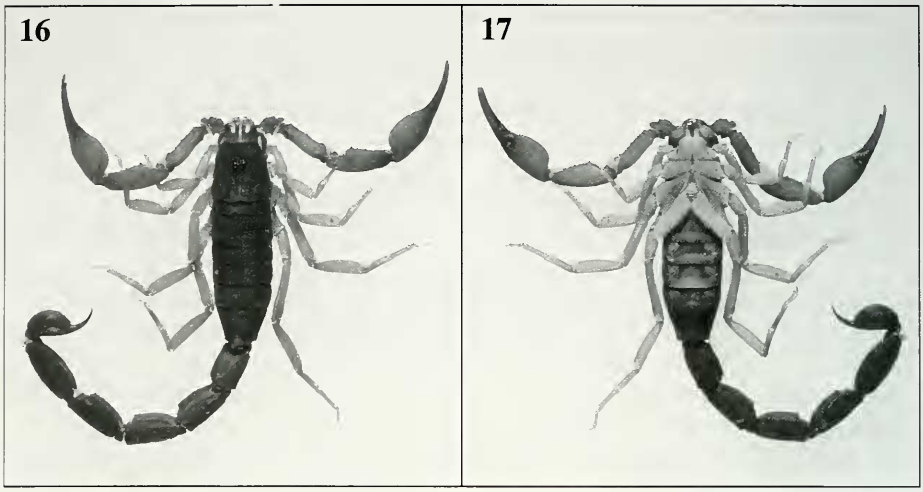
ETYMOLOGY: This patronym is in honor of Jules Goudot, collector of the first *Grosphus* species in Madagascar.

DIAGNOSIS: Scorpions of medium size, with a total length of 60 mm. General coloration reddish brown to dark brown. Certain morphological characters indicate that *G. goudoti* sp. n. is close to the *G. madagascariensis/G. hirtus* group, and in particular to *G. simoni* Lourenço, Goodman & Ramilijaona, 2004 but it can be readily distinguished from the last species by the following characters: (i) a much darker coloration of carapace and tergites, with the presence of one inverted black triangle in the anterior zone of the carapace, stretching from the lateral eyes to the median eyes; (ii) the teeth of pectines longer than in *G. simoni*; (iii) dorsal carinae of metasomal segments II to IV without any posterior spinoid granules.

DESCRIPTION: (based on male holotype, measurements in Table I)

Coloration. Basically reddish brown to dark brown. Prosoma: carapace reddish brown with one inverted black triangle in the anterior zone of the carapace, stretching from the lateral eyes to the median eyes; eyes surrounded by black pigment. Mesosoma: reddish brown, with dark strips on posterior margins of tergites. Metasoma: segments I to III reddish brown; IV-V dark brown; all segments with some vestigial dark pigmentation on carinae. Telson reddish brown, with dark zones on granulations; aculeus with reddish brown base and dark brown tip. Venter: coxapophysis, sternum, genital operculum and pectines yellowish; sternites yellow with greenish zones; VII dark brown. Chelicerae reddish yellow, with dark variegated pigmentation on the entire surface; fingers reddish brown; teeth reddish. Pedipalps: reddish to reddish brown; chela fingers dark brown. Legs yellowish, with very diffused variegated spots.

Morphology. Carapace covered with a thin but intense granulation; anterior margin almost straight, with a very weak median concavity. All carinae weak; furrows moderately developed. Median ocular tubercle anterior to centre of carapace; median eyes separated by one ocular diameter. Three pairs of lateral eyes. Sternum sub-triangular in shape. Mesosoma: tergites with thin but intense granulation. Median carina moderately developed on all tergites. Tergite VII pentacarinate. Venter: genital operculum consisting of two semi-oval plates. Pectines: pectinal tooth count 19-19, basal middle lamellae of each pecten not dilated in males. Sternites smooth, with moderate-

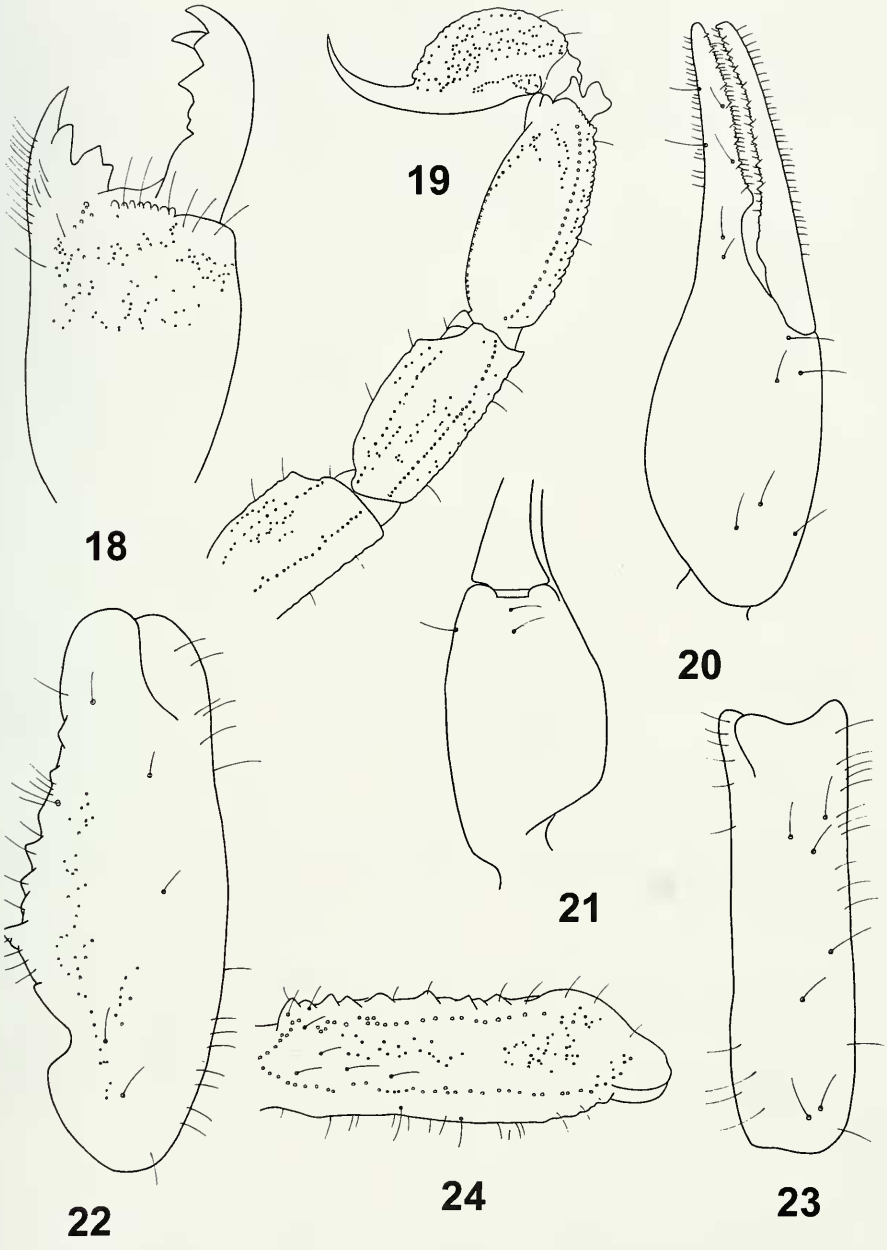


FIGS 16-17
Grosphus goudoti sp. n. Male holotype, dorsal and ventral aspects.

ly elongated spiracles; VII with four weak carinae. Metasoma: segments I and II with 10 carinae, moderately crenulate; segments III and IV with 8 carinae, weakly crenulate. Segment V with 5 carinae. Dorsal carinae on segments II to IV without any posterior spinoid granules. Intercarinal spaces moderately to weakly granular. Telson moderately granular over latero-ventral and ventral surfaces; its dorsal surface smooth; aculeus moderately curved and shorter than the vesicle; subaculear tooth vestigial. Cheliceral dentition characteristic of the family Buthidae (Vachon, 1963); two distinct basal teeth present on the movable finger; ventral aspect of both fingers and of manus densely set with long setae. Pedipalps: femur pentacarinate; patella with dorsointernal and ventralinternal carinae and with some strong spinoid granules on the internal aspect; chela smooth, without carinae. Fixed and movable fingers with 11/12 oblique rows of granules. Trichobothriotaxy; orthobothriotaxy A-α (Vachon, 1974, 1975). Legs: tarsus with numerous short thin setae ventrally. Tibial spurs present on legs III and IV; pedal spurs present on legs I to IV; all spurs strong.

Female unknown.

ECOLOGY: The site where the holotype of *Grosphus goudouti* sp. n. was collected is in a forested area forming an exceptional zone of ecotonal transition in the central portion of northern Madagascar. This is known as the Daraina Forest, named after the largest local village. This area is biotically very complex and the remaining forests are greatly reduced in size and fragmented. In a distance of a few kilometres there are transitions between dry deciduous forest formations prevailing in the west and humid forests prevailing in the east. Elevation, aspect, soil type, and distance to the sea are important parameters associated with these transitions. The site where the holotype of *G. goudoti* sp. n. was collected is composed of dry deciduous lowland forest



FIGS 18-24

Grosphus goudoti sp. n. Male holotype. 18. Chelicera, dorsal aspect. 19. Metasomal segments III-V and telson, lateral aspect. 20-24. Trichobothrial pattern of pedipalp. 20-21. Chela, dorso-external and ventral aspects. 22-23. Patella, dorsal and external aspects. 24. Femur, dorsal aspect.

FIG. 25

Map of Madagascar, with indication of the sites were *Grosphus madagascariensis* and *G. hirtus* have been collected, and the locality of the new *Grosphus* species. *G. madagascariensis* (black star), *G. hirtus* (black circle), and *G. goudoti* sp. n. (black circle with white star).

that is relatively intact, with little leaf litter, relatively open understory, which rests on reddish lateritic soils.

Other species of scorpions known to occur in the forests of the Daraina area are *Heteroscorpion magnus* Lourenço & Goodman, 2002, *Tityobuthus darainensis* Lourenço & Goodman, 2002, and *Grosphus darainensis* Lourenço, Goodman & Ramilijaona, 2004 (Lourenço and Goodman, 2002; Lourenço *et al.*, 2004).

KEY TO THE SPECIES OF THE GENUS *GROSPHUS*

1 Pectines with a maximum of 21 teeth 2
- Pectines with more than 22 teeth 7
2 Coloration yellowish to reddish brown; variegated brownish pigmentation present 3
- Coloration from yellowish to reddish brown or dark brown; variegated brownish pigmentation absent 4

3 Coloration reddish brown; adult body length 30 mm . . . . . *G. garciai*
- Coloration yellowish; adult body length 40-50 mm . . . . . *G. hirtus*
4 Metasomal segments II-IV with one or more spinoid posterior granules 5
- Metasomal segments II-IV without any spinoid granule . . . . . *G. goudoti* sp. n.
5 Metasomal segments II-IV with one spinoid posterior granule 6
- Coloration reddish yellow; dorsal carinae of metasomal segments II-IV with 2 to 6 strong spinoid posterior granules . . . . . *Grosphus simoni*
6 Coloration yellowish; dorsal carinae of metasomal segments II-IV with one small spinoid posterior granule . . . . . *Grosphus darainensis*
- Coloration reddish to dark brown; metasomal segments II-IV with one strong spinoid posterior granule . . . . . *G. madagascariensis*
7 Coloration blackish or reddish brown to yellowish; pectines with 30 to 40 teeth; adult body length more than 90 mm 8
- Coloration reddish brown to yellowish, never blackish; adult body length less than 90 mm 9
8 Coloration blackish throughout . . . . . *G. grandidieri*
- Coloration reddish brown to yellowish . . . . . *G. ankarana*
9 Mesosoma with homogenous coloration, reddish brown or yellowish 10
- Mesosoma with a blackish longitudinal median band, or with two blackish longitudinal lateral bands 15
10 Adult total length more than 65 mm; mesosoma reddish brown . *G. flavopiceus*
- Adult total length less than 60 mm; mesosoma dark yellow; metasomal segment V and telson with or without blackish spots 11
11 Metasomal segments and telson without blackish spots 12
- Metasomal segments and telson totally blackish or with blackish spots 13
12 Metasomal segments yellowish, with moderately to strongly developed carinae on II to IV . . . . . *G. intertidalis*
- Metasomal segments reddish yellow; rounded and with vestigial carinae . . . . . *Grosphus mahafaliensis*
13 Metasomal segment V and telson with blackish spots . . . . . *G. annulatus*
- Metasomal segment V and telson totally blackish 14
14 Telson with aculeus of the same length or shorter than the vesicle . . . . . *G. feti*
- Telson with aculeus longer than the vesicle . . . . . *G. olgae*
15 Mesosoma with a wide blackish longitudinal median band; basal middle lamellae of female pectines three times longer than wide at their base and covering the four proximal teeth . . . . . *G. limbatus*
- Mesosoma with two narrow blackish longitudinal lateral bands 16
16 Carapace without a blackish triangular spot; basal middle lamellae of female pectines weakly curved, widening in proximal half and covering the two proximal teeth . . . . . *G. bistriatus*
- Carapace with a blackish triangular spot; basal middle lamellae of the female pectines curved and constantly narrowing from the base to apex, covering the four proximal teeth . . . . . *G. ankarafantsika*

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